S-5/PHSH/CC-11/22

TDP (Honours) 5th Semester Exam., 2022

PHYSICS

(Honours)

ELEVENTH PAPER : CC – 11

Full Marks : 60 *Time* : 3 Hours

Answer from ***both*** *the Groups as directed.*

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP—A

1. Answer *any* **six** of the following questions : 2×6=12

(a) What is gyromagnetic ratio?

(b) What is the energy of the electron in the *n*th orbit of H_2 atom?

(c) State Hund's rule.

(d) What do you mean by Na-D lines?

(e) What is L-S coupling?

(f) Write the role of rotational quantum number in the energy expression of rigid rotator.

(g) What do you mean by normalization constant?

(h) Write two differences between Stark effect and Pasehen-Back effect.

GROUP—B

There are *four* questions from Question No. 2 to Question No. 5. Answer either *(a)* **or** *(b)* from each question given below : 12×4=48

2. *(a)* *(i)* From Schrodinger time dependent equation in 3-D, find the normalised momentum eigenfunction. From this find the probability of momentum lying between p and $P + dp$.

(ii) For Gaussian wave packet, show that the uncertainty relation holds for position and momentum.

(iii) Considering $\psi(r) = \frac{1}{r} e^{ikr}$

Where $r = \sqrt{x^2 + y^2 + z^2}$

calculate the value of current density J.
(4+2)+3+3=12

(OR)

(b) *(i)* A Gaussian wave packet is given by the equation

$$\psi(x, 0) = \frac{1}{\left(2\pi\sigma_0^2\right)^{\frac{1}{4}}} e^{-\frac{x^2}{2\sigma_0^2}} \exp\left(\frac{l^0}{\hbar} P_x\right)$$

Find the time evolution of the wave function.

(ii) What is the physical significance of commutation relation in quantum mechanics? Evaluate $[y, P_y]$.

(iii) Set the equation which gives the propagation of expectation value of position w.r.to time and show its relation with the expectation value of momentum. 4+(2+2)+(2+2)=12

3. *(a)* *(i)* The wave function of a particle of mass m is moving in a potential $V(x) = \alpha^2 x^2$ is

$$\psi(x) = \exp\left(-\sqrt{\frac{m\alpha^2}{2\hbar^2}} x^2\right)$$

α is a const. Find the energy of the system.

(ii) In case of harmonic oscillator, for a large value of n, show that the average value of $|\psi_n(x)|^2$ is in good agreement with the corresponding classical value.

(iii) Write the boundary condition and condition of continuity for the wave function. 5+4+3=12

(OR)

(b) (i) A particle of mass m confined to move in a potential $V(x) = 0$ for $0 \le x \le a$ and $V(x) = \propto$ otherwise. The wave function for the particle is given by

$\psi(x, 0) = A \sin\frac{5\pi x}{a} \cos\frac{2\pi x}{a}$. Normalise $\psi(x, 0)$.

Find $\psi(x, t)$ and compare the state of normalisation of the two wave functions.

(ii) What physical significance can you interpret from the above observation?

(iii) Set the Schrodinger equation of hydrogen atom for spherical polar co-ordinates. Find the radial part of the wave function and hence evaluate R_{20} (2+2+2)+(4+2)=12

[Continued]

4. (a) (i) Write some differences between characteristic and continuous X-ray spectra.

(ii) Describe briefly the Stern-Gerlach expt. Explain the result of the experiment.

(iii) Physically explain what you mean by Bohr magneton.

3+(5+2)+2=12

(OR)

(b) (i) What will be the separation between the adjacent normal Zeeman components for emitted radion of 4500Å in a magnetic field of 4 Tesla?

(ii) Find the velocity of the electron in the ground state of Bohr's hydrogen atom in terms of speed of light. What is this called?

(iii) What is vector atom model? Write down the electron configuration for Cu(29) using modern symbolism.

4+(3+1)+(2+2)=12

5. (a) (i) State Pauli Exclusion Principle and give an example which can support the principle.

(ii) What will be the state of wave function in case of exchange of co-ordinate of any two electrons, with respect to symmetry? Write the basic difference between hydrogen spectra and alkali spectra.

(iii) Find the possible values of resultant angular momenta for two electrons with $j_1 = \frac{3}{2}$ and $j_2 = \frac{5}{2}$. 3+2+3+4=12

(OR)

(b) (i) Write the difference between the rotational and vibrational spectra of a diatomic molecule.

(ii) To have a vibrational spectra why the atom should be heterogeneous.

(iii) With a clear diagram, show the spin orbit coupling for alkali like atom.

(iv) Calculate g factor for $^2P_{\frac{3}{2}}$ and $^2S_{\frac{1}{2}}$ states. Is there any role of g factor in spectral transitions? 3+2+4+3=12

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S-5/PHSH/CC-12/22

TDP (Honours) 5th Semester Exam., 2022

PHYSICS

(Honours)

TWELFTH PAPER : CC – 12

Full Marks : 60 *Time* : 3 Hours

Answer from ***both*** *the Groups as directed.*

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP—A

1. Answer *any* **six** of the following questions : 2×6=12

(a) Write two important differences between crystalline and amorphous solids.

(b) What are Bravais lattices?

(c) Define Debye's T^3 law.

(d) State Wiedemann-Franz Law.

(e) What do you mean by Meissner effect?

(f) What is London penetration depth?

(g) Explain the concept of ferroelectricity.

(h) What is exchange interaction in ferromagnetism?

GROUP—B

There are *four* questions from Question No. 6 to Question No. 9. Answer either *(a)* **or** *(b)* from each question given below : 12×4=48

2. *(a)* *(i)* Describe different types and natures of crystal binding.

(ii) State and prove Bragg's law of X-ray diffraction and verify it for a Nacl crystal at glancing angle of 8·8°.

(iii) Draw (101) and (111) planes in a cubic unit cell and determine the Miller indices of the directions which are common to both the planes.

4+(1+3+1)+3=12

(OR)

(b) *(i)* Determine volume of a unit cell, atoms per unit cell, coordination number and atomic packing fraction of B.C.C. crystal structure.

(ii) Describe the powder method of X-ray diffraction and discuss the usefulness of this method.

(iii) Why cannot ordinary optical grating diffract X-rays?

4+(4+2)+2=12

3. (a) (i) Derive the dispersion relation for lattice vibration of a one dimensional diatomic lattice and discuss the different branch of dispersion curve with diagram.

(ii) What is Debye temperature? Write its significance.

(iii) If a solid has the Debye temperature of 2000°C, what is its room temperature in specific heat? (3+3)+(1+2)+3=12

(OR)

(b) (i) Write the salient features of the Einstein's theory of lattice heat capacity.

(ii) Derive an expression for the lattice heat capacity following Einstein's model and show that at low temperature it drops exponentially with decreasing temperature.

(iii) Which properties of metals are explained by free electron gas theory? 3+(4+2)+3=12

4. (a) (i) Discuss Kronig-Penny model to describe the motion of an electron in a periodic potential.

(ii) Show from (E-K) graph that materials can be classified into conductors, insulators and semiconductors.

(iii) What is Hall effect? Show that Hall co-efficient is inversely proportional to the current density and electronic charge. 5+3+(1+3)=12

(OR)

(b) (i) Write the differences between semiconductor and normal conductor.

(ii) What do you mean by critical Magnetic field in superconductivity? How does it vary with temperature in type-I and type-II superconductors? Explain with diagram.

(iii) Describe BCS theory to explain superconducting state. 2+(2+4)+4=12

5. *(a)* *(i)* Derive the quantum theory of paramagnetism and discuss the Low and high-temperature cases.

(ii) Explain the cause of hysteresis phenomenon in ferromagnetic materials. What does area of the loop signify?

(iii) Explain the domain theory of ferromagnetism.

(4+2)+(2+2)+2=12

(OR)

(b) *(i)* Derive the Clausius Mossotti equation between polarisability and dielectric constant of solid.

(ii) Explain the polarisability of atoms. Write the difference among electronic, ionic and orientational polarisabilities.

(iii) What is electrostrictive effect?

(2+4)+(1+3)+2=12

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